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Importance of Indigenous Knowledge in Flood Risk Reduction: A Review

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ABSTRACT

Interest in Indigenous Knowledge (IK) system has been particularly highlighted in flood disasters, due to the likely increase of flood events resulting from anthropogenic climate change through heavy precipitation, increased catchment wetness, and sea level rise. Therefore, bringing IK of flood risk reduction into focus and context to deepen the understanding of how people manage their own changing circumstances can bring more pertinent information about flood risk reduction. This paper reviews the significance of IK in flood risk reduction. Specifically, the paper discusses IK flood forecasting, early warning signs, adaptation and coping strategies in flood risk reduction around the world. The Methodological approach employed for this paper is the review of existing literature on IK in flood Disaster Risk Reduction (DRR), and then a summary of the outcomes of the studies reviewed was discussed. However, it was deduced from the review undertaken, the need for an intensive empirical study to be conducted to explore how efficient these strategies or techniques are, in relation to flood risk reduction, which this paper strongly recommends for further investigation. Additionally, the paper concludes by emphasizing that although the IK of flood risk reduction is embedded in varied regions around the globe, still there is a need for further study to be carried out in order to unveil why the similarities and variations in flood risk reduction practices/strategies between regions.

Keywords:
Indigenous knowledge, flood, adaptation, coping, forecasting, flood warning

1. Introduction

Various communities and individual attention on floods have increased dramatically in recent time as a result of climate change, particularly due to constant and severe rainfall experience, rapid population growth, urbanization, sea level rise, flood risk awareness, the exposure and vulnerabilities of enormous numbers of people around the world [1-4]. Based on the report of the Intergovernmental Panel on Climate Change (IPCC), projected the escalation of the world surface

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air temperature average from the year 1990 to 2010 falls between 1.4°C and 5.8°C [5-6]. Additionally, as scientific evidence keeps on unfolding, global warming is becoming a reality and the entire globe is compelled to adapt to a changing climatic condition [7-8]. However, Climatic modeling shows that precipitation will increase in some areas, more especially in the monsoonal regions, and these changes have to do with the rate and intensity of extreme situations like flood disaster among others [9-11]. Increased rainfall, wind events along the coasts and Sea-level rise could significantly influence flood risk and its frequency in different parts of Asia, Africa and Latin America [12]. In view of this, IK especially of flood risk reduction is a more participatory and a veritable resource becomes paramount, considering the fact that over the years the hard infrastructure and scientific technologies used in flood management and control have proven inadequate enough in curbing the menace associated with flood disasters as demonstrated by the incessant flood occurrence around the world. In view of these facts, value of IK in flood DRR is increasingly gaining more attention [13]. IK has immensely played a critical role in making local communities around the world to live in harmony with the peculiarities of their various environmental conditions for a considerable time has contributed to improving knowledge concerning their environments. More often, this knowledge is applied in the form of coping strategies, adaptation, monitoring the weather and seasonal predictions [14]. The indigenous communities in the rural and urban settings around the world are confronted with varied hazards among which is increased flood risk which has a link with climate change and in order to manage such hazards, communities apply Indigenous community-based techniques derived from years of experience living with a particular environmental condition [15-16]. This paper, however, undertakes a review of IK in the reduction of flood risk. This is to demonstrate the significance of IK in flood risk reduction and more especially as it can fill the gap in case the structural and scientific approaches fail. However, the paper concentrates on the relevance of IK in flood risk reduction through IK flood forecasting, flood early warning, coping and adaptation strategies practiced by vulnerable communities globally.

2. Methodology

A review of existing literature on IK in flood risk reduction was carried out. The objective of adopting this approach was to find the articles of studies that discussed the importance of IK in flood DRR. In addition, an electronic search was carried out by the use of Google Scholar search engine to sort-out for articles ranging from 2000-2017 in which the following search terms were included: (a) indigenous knowledge (b) flood (c) disaster and (d) reduction. Also, a lot of studies were found via the manual review of reference lists of past studies. In addition, studies that were carried-out of recent, that were related to the subject matter were identified via the following databases: Science Direct, Springer, Tailor and Frances online, Sage, Emerald, Wiley and Francis online library, Scopus, Digital Library and Web of science. Specific studies for this review were deemed eligible having met the following criteria (i) if the study focuses on the importance of IK in the reduction of flood risk (ii) peer-reviewed. The importance of IK in the reduction of flood risk was drawn from a worldwide literature, with no restriction to a particular case study area.

3. Results and Discussion

3.1 Flood Forecasting

Indigenous flood forecasting for the prevention of flood risk is practiced among floodplain residents in varied communities around the world; this is because of the inherent danger associated with floods, and its negative consequences on residents of such danger-prone areas.

This made them to develop the ability of forecast by applying their IK in order to get much prepared. This is demonstrated by studies conducted by Okonya and Kroschel [17] that study the prevalent IK of forecasting the time and volume of rain in the raining seasons of the six regions of Uganda. The study reveals that the prediction at the beginning of any rainy season, which is likely to be associated with flooding, some of these indicators were highlighted; the blowing of the wind from the west to the east direction, cuckoo birds begin to call, and also winged termite swarms desert their nests. The study indicates that indigenous indicators play important roles in rain forecasting as well as improving the timing of flood and agricultural activities.

In contrast to Okonya and Kroschel and Chang *et al*., [17-18] described how farmers living in the Highland of South Western Tanzania forecast rainfall through the usage of local environmental indicators and astronomical factors. The study reveals that plant phenology is enormously applied by indigenous communities in forecasting seasonal rainfall. Furthermore, the study highlights that early flowering of Mihemi (Erythrina abyssinica) and Mikwe (Brachystegia speciformis) trees from the month of July to November has been noted to be one of the signals of good rainfall season. Similarly to Okonya and Kroschel [17], the behavior of Dudumizi bird is also singled out as one of the best indicators of rainfall. [19] Studied the role of IK in weather and climate forecasting in Mahenge and Ismani wards in Tanzania. Also in line with Okonya and Kroschel and Chang *et al*., [17-18], the study also identifies that plant phenology, especially mango trees were discovered to be the most used indicators in both wards. This is worthy of note that plant phenology is one of the important factors in rain prediction as shown by these various studies. However, Devkota and Cockfield [20] assessed the flood adaptation techniques that are used at the community level in two Terai districts of Nepal. The study discovered that flood forecasting activities at community level includes observing the extent of rainfall in upper catchments and noting the position of clouds. The study went further to state that 'Initiate communication', 'take care of the vulnerable people', and 'choose the appropriate destination to stay' was considered the most preferred strategies during flood outbreak.

Santha [21] confirmed that IK systems are inbuilt elements of the people's capacity to foresee natural hazards and invariably mitigates the disaster risk. The study stressed that IK systems exist within traditional fish workers in Kerala for the prediction of coastal hazards. The study indicates that the nature of coastal hazards is demonstrated through kolu which is a holistic phenomenon. They further state that the IK linked with the forecasting and prediction in kolu is however explained in relation to biotic, atmospheric, oceanic and celestial spheres. The study recommends the need for indigenous CB early warning systems that are rooted in the livelihood of the world marginalized resource-dependent communities. All these studies conducted did not, however, discuss how effective these IK flood forecasting strategies have served over the years which are very crucial to the findings of all the studies.

3.2 Flood Early Warning Signs

Macherera [22] describes a Community Base (CB) early warning system as flood hazard identification by indigenous communities and evolving warning systems, and not just responding to a warning at the local level. However, Glantz [23] argued that an early warning system comprises of many components not only the issuance of a warning. He stressed that a comprehensive early warning system involves the identification of the warning, the notification of the warning, and response to the warning. The early warning system is an integral part of the indigenous CB disaster risk control. Most of the indigenous CB early warning systems are often monitored by the community themselves, thus empowering them and at the same time ensuring the stability of the

system. Hence, there have been studies conducted to demonstrate the applicability of flood early warning signs in the prevention or reduction flood risk like the study by Glantz [23] examined the early warning signs associated with climate change as shown by the Borana inhabitant of Isiolo County in Kenya. The main purpose of the study was to know the indigenous early warning signs applied by the Borana community in predicting the onset of rainfall and possible floods outbreak. The findings of the study reveal that the Borana has different indigenous early warning signs for the detection of weather changes. These include animals' behavior, the presence of typical insects, clouds formation, coloration of the intestines of slaughtered domestic animals, plants flowering and the pattern of stars. The paper emphasized that the early warning signs of weather variations are very valuable as it helps the community to apply the most appropriate coping technique when confronted with flood calamity. In conclusion, the study suggests the combination of the IK early warning indicators in Borana with modern forecasting methods, in order to make them more appropriate. Becker *et al*., [24] discussed the nature of traditional knowledge and its contribution to emergency management. Specifically, the paper investigates a case study in which an Indigenous Native American story was combined with an educational clip for tsunami hazard management. The findings of the study show that IK can be utilized to undertake hazard education and at the same time enhance response to flood early warnings. The video, entitle "Run to Higher Ground!" is a classic example, and has since been adopted by indigenous communities and the population in general (both in the USA and internationally) as an educational tool. Thus, from the above, it can be inferred that IK early warning systems are inbuilt within a particular community depending on its peculiarity.

3.3 Adaptation Strategies

Additionally, varied researches have been undertaken to demonstrate the significance of adaptation strategies in flood risk reduction. Hazarika *et al*. [25] describe the complex human–flood disaster interactions from the chronically flood-impacted district of Dhemaji in the Upper Brahmaputra floodplain. The objective of this study is to analyze perceptions, vulnerability and IK adaptations that warrant co-existence of floods and the residents of the floodplain. The study indicates a realistic perception of flood risk within the floodplain residents. Furthermore, the study highlights that vulnerability is higher in the research area as a result of lack of infrastructure. Also, IK adaptation techniques in the area include repairing of embankment through the use of sandbags, tree logs, and bamboo. Also, residents use boats for rescue operation during floods, planting of flood resistant crops and dwellings a built on raised platforms. All these warrants the floodplain residents to live with floods in a sustainable manner. The study was specifically based on Upper Brahmaputra River floodplain which stands as a contribution towards the long-standing discourse on the preference human beings take in reacting to riverine hazards. Also, Devkota *et al.*, [26] explored IK for climate change induced flood adaptation in Nepal. The research findings reveal that there are very efficient indigenous flood prediction practices like examining the position of the clouds, analyzing the movement of ants, monitoring the level of rainfall in catchments, analyzing the magnitude of hotness and hearing strange sounds from river torrents and analyzing the extent of thunderstorms and the wind blows. The synthesis, as well as the analysis of these indicators, assist communities to prepare for possible flood occurrence through the creation of drainage systems in each plot of land, storage of valuable materials, psychological preparation of floods and preparation for search and rescue operation. Not-with-standing the paper argues that IK flood prediction and adaptation strategies could be especially utilized by migrants that are in flood-prone areas but not informed of the practices in another part of the country.

However, Hernández-Guerrero *et al*., [27] examined the adjustment strategies demonstrated by indigenous communities living in a precarious housing situation in two flood-prone settlements found in the periphery of the city of Morelia in Mexico. The discussion was made on how these strategies interfere with the adaptive capabilities of these settlements in relation to future flood events. The study indicates that poverty and housing precariousness is responsible for the formation of new dwellings in areas that are not fit for urban development because of extreme flood conditions. The extreme flood condition is further enhanced by poor planning techniques and rudimentary housing improvements by residents. The latter serves as an adaptive process by which the residents adjust to risk after flood outbreak.

On the other hand, Mercer *et al.*, [28] examined flood risk in the global South, and how risk perceptions influence how local government and residents manage disasters. The study indicates that local residents' risk perceptions are affected by the longtime relationship of distrust with local government. Local government official's states that a challenge such as limited capacity in implementing policies contributes in limiting the efficiency of local government's capacity to manage flood-related risks. And in looking at how adaptive capacity can be enhanced in the cities in the global south, the potentials in local government and indigenous community capacity to work in a complementary manner was advocated. However, Haque *et al*., [29] studied the significance of community-based approach to mitigating sea level rise vulnerability and enhancing resilience capabilities of the residents in the coastal areas of Bangladesh. The study argues that local level CBA approach is good in resilience building among the most vulnerable groups of the society as well as the involvement of the community in the decision-making process is also very crucial for a successful resilience building process in the coastal areas. The study noted the gap in the government policies and strategies at both National Adaptation Program of Action (NAPA) and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) for giving little attention to CBA priorities. The study emphasized that indigenous community participation is very important and needs to be incorporated into the broader national strategies for developing an efficient adaptation and social-ecological flood resilience system.

While Anik *et al*., [30] appraised climate-related perception and noted various adaptation strategies in the low-lying settlements of North-Eastern Bangladesh. It was noted that the main climate activities in the study include temperature change, storm surges, heavy rainfall etc. However, the major livelihood problems emanating from these events were lack of fish availability, scarcity of water in dry seasons and frequent flooding during rainy seasons. The study uncovers that ten percent of the respondents are informed about climate change. Furthermore, seasonal livelihood and hazard calendar reveal that indigenous people are every day changing their livelihood status due to climatic variation hazards more especially flooding. The study concluded by emphasizing that indigenous people always try to adapt to the changing climatic condition by way of changing their behavior and evolving new adaptation strategies. Also, Dewan and Islam [31] examined the impacts of the flood on char livelihoods and adaptation techniques by the local people. The study also revealed that as floods persist; most farmers couldn't work on their farmlands and couldn't meet up with the basic needs of their respective families because the flood water covers their farmlands for about two to three month, which resulted in non-crop production at that particular time frame. In addition, the paper indicates that people as of then live on roads, schools and at the top of their roofs because there was no provision of flood shelters. Apart from that, there was inadequate rehabilitation program. It was also discovered that siltation reduced the fertility and productivity of the agricultural land in the area. As part of coping strategy, farmers were encouraged to grow flood-tolerant varieties of crops in the area to mitigate the loss of production and in order to live a sustainable life with future flood outbreak.

Aris *et al*., [32] investigated the indigenous community responses and adaptation techniques to flood disaster employed in Jakarta. The study reveals that exposure to flood risk is on the increase, and it is linked to many factors: communities, environment, stakeholder and infrastructure and its maintenance. However, varied adaptation strategies have been adopted by the indigenous communities, which include raising the housing level, building small dikes to prevent water entering the settlements and building terraced housing. Also, non-physical adaptation strategies were noted from the fieldwork. These adaptation strategies include communal work and the reuse of resources and materials that are not destroyed by a flood. Additionally, uncoordinated reactions during flood outbreak do result to more vulnerability to the hazard. The study argues that urgent attention should be given to enhancing the institutional and stakeholders connection, particularly at the municipal level, because it is assumed they provide more effective disaster response. Similarly, Bauer and Hall [33] examined household exposure and responses to floods in Udayapur district, Nepal. The study highlight how indigenous communities in the region handle flooding, as well, as the extent their preventive and adaptation strategies have worked in preventing loss and damage. The study revealed the types of strategies families employ in relation to floods. In situ measures – like the use of sandbags, bamboo fences, and stone walls – are the most used techniques to manage floods and the prevention of impacts.

In the contrary, Molina [34] examined the intergenerational transfer of indigenous IK in relation to flood risks reduction and adaptation in Dagupan city in the Philippines. The study reveals that Dagupeños develop local knowledge to adapt to flood risks over time. In looking at the said knowledge, its intergenerational transfer was traced to the following generations: before 1990, 1991–2000 and 2001 to date. The study also emphasized that through the enhancement of intergenerational IK with urban disaster control; there will be a good understanding of changes in risk perception and at the same making risk mitigation more sensitive to varied sectors in urban settlements. Also, the study stressed that the determination of impacts from one generation to another will warrant communities to have a more comprehensive approach to disaster control. The study concluded by stating that identification of IK that can address thematic concerns on flood DRR such as readiness, prevention, reduction, and the response would enhance decentralized governance more especially in vulnerable poor Communities.

However, Mcewen [35] explored results from an interdisciplinary study on ‘sustainable flood memory’ within the context of flood risk control as a contribution to a global priority. The study was targeted to increase the understanding of the way flood memories assist in creating a platform for evolving and disseminating lay knowledge in order to increase communities’ adaptive abilities for resilience. The study begins by conceptually framing resilience, flood memory and community lay knowledge. It then explores the main themes obtained from the floodplain residents impacted by the UK summer 2007 flood disaster in four different settings, which was contrasted in terms of their flood histories, experiences, and kinds of ‘communities’. Sustainable flood memories were discovered to be linked with relational ways of knowing, which is situated in emotions, community tensions and changing materiality. Undoubtedly, the study reveals that all these affect active remembering and also active forgetting. The study considers varied integrations of memory, resilience and lay knowledge, and also evaluates the repercussions of the sustainable flood memory concept in relation to the strategy, process and practice of developing indigenous community flood resilience. Considering the concept’s value of ‘memory work’, the study suggested a guide for the translation of this concept in practical terms for indigenous community resilience initiatives.

3.4 Coping Strategies

There are varied ways in which groups of inhabitants of floodplain cope with flood disaster. Grouping these techniques can amount to a more complex system of interconnections. Twigg [36] groups them such as economic, technological and socio-cultural techniques. These techniques are put in place before the occurrence, during and after the flood disaster. 'Preventative strategies' are worked out to cushion the severity of flooding and are put in place before the flood disaster impacts [37]. Indigenous communities living in flood marginal areas in some cases look for alternative food from the fields or rather from the forests, also as part of response strategies; they also seek income from extended kinsmen and other friends in order to meet up with their economic needs within the period of the flood [37]. Also, Floodplain residents sometimes may utilize the occurrence of flooding through partaking in fishing activities, lily tuber harvesting or rather reed crafts. After the application of flood disaster response strategies, on the other hand, is 'recovery' strategy. And basically, this includes the act of cleaning, renovations of affected buildings among others, developing new social networks etc. [37].

There are varied studies that were carried out to show the significance of indigenous coping strategies. Mercer *et al*., [38] explored the local people survival strategies and assesses variation in people's ability to cope with flood and riverbank erosion of two char land (Mid-channel Island) villages of Bangladesh. The study revealed that household's capacity to cope with floods and river erosion is dependent on people's socio-economic conditions such as education, income, and occupation. The study went further to highlight that although flooding and river erosion resulted in the destruction of lives and properties, people's indigenous coping techniques significantly reduce their vulnerability without demanding outside assistance.

Similarly, Mavhura *et al*., [39] explore indigenous survival strategies and variations in people's ability to cope with the flood. The study indicates that IK systems played an important role in mitigating the effects of floods in Muzarabani district. However, the extent to which IK improves resilience to floods was governed by geophysical locations, socio-economic capabilities and exposure to floods. The study emphasized that IK systems are significant components of disaster resilience. This is because IK systems can be quitted and adapted by other communities; enhances public participation and empowerment of affected communities, is usually beyond formal education in relation to environmental hazards.

In contrast, Irfanullah and Motaleb [40] summarized the endeavor of Haor residents in Bangladesh in dealing with post-flood situation by partaking in floating garden indigenous farming technique as a result of intense motivation, determination and capacity development. They state that floating gardens and winter vegetable farming were discovered to be helpful for promoting nutritional security, household income, and land use capacity of the extremely poor and landless people, particularly during the post-flood disaster period.

On the other hand, Hooli [41] confirms that past experience counts in flood resilience in his study indigenous communities coping strategies to withstand flood events from the perspective of socio-ecological resilience. The focus was placed on the learning processes that improve the residents' ability to cope and the role of IK. IK has been identified as a source of resilience in both theory and practice because it is based on past learning and experiences of natural hazards. The study also reveals that floods are caused due to complex and relational development not necessarily linear relationship between the causes and effects. The study argues that instead of focusing on the communities' capacity to self-organize, the focus on resilience building needs to be directed to the broader socio-political processes, which are making the communities vulnerable in the first place.

But, Ringo *et al.* [42] examined the role of IK in flood control in Kilosa District in Tanzania. The study reveals that people planted native vegetation, contouring and terracing their farms, swimming, running, climbing trees and roofs of their dwellings to cope with floods. The study recommended that IK should be incorporated with the culturally sensitive scientific knowledge that fits the domain of the local people. The study went further to stress that, local people should be made to recognize and value their IK and how they can contribute to prevent or reduce flood risks. The study advised that this can be achieved through organizing workshops and training programs at the local level.

From the foregoing, IK can be seen as a powerful resource relating to flood risk reduction. Residents of flood marginal areas around the globe have evolved their IK of flood risk reduction based on the peculiarities in their various localities in order to handle the environmental threat of flood disaster they are bedeviled with. The review undertaken revealed that IK of flood risk reduction is applied in varied forms ranging from flood forecasting, early warning signs, adaptation and coping strategies. All these are evolved in different regions around the globe as a result of the long-time habitation of the residents of such flood marginal areas as well as the experiences acquired, which to a great extent have assisted them to come up with measures of mitigating the negative impacts of flood risk reduction. Also, from the review as point of emphasis IK of flood risk reduction is an endowment in different places which has played a critical role in salvaging lives and properties in time in memorial up to this present time. It is an undeniable fact that IK has a great relevance in flood risk reduction as demonstrated in various studies reviewed. However, it is obvious from the review undertaken above, the need for an empirical study to be carried-out to explore how efficient these strategies or techniques are, in which this study recommends for further investigation. Also, considering the fact that IK of flood risk reduction is embedded in different regions around the world, more needs to be unveiled about the similarities and variations in flood risk reduction practices/strategies in different regions around the world.

5. Conclusion

The review demonstrates the relevance of IK in flood risk reduction in relation to flood forecasting, flood early warning, flood adaptation and coping strategies in varied communities around the world. However, it was inferred that there is the need for an empirical study to be carried-out as evidenced by the review undertaken, that will specifically explore how efficient these strategies or techniques are, in flood risk reduction. This paper recommends for further investigation. Additionally, the paper concludes by stressing that although the IK of flood risk reduction is embedded in varied regions around the globe, still there is a need for further studies to be undertaken in order to discover why the similarities and variations in flood risk reduction practices/strategies between regions.

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